giving an account of his experiences, made an appeal to the meeting for increased support to carry on the work of exploration, which was at present flagging for want of funds. He urged the subscribers to the Fund to complete the work of surveying the country as soon as possible, as the land, being so fertile, was constantly being taken by the Greeks and other foreign cultivators of the soil for farming purposes. As a consequence, the old names of the towns and villages were fast disappearing, and the whole country was assuming a different aspect. This meeting was the first of a series that is to be held, information as to which can be obtained of the secretary at the office of the Fund, 9, Pall Mall East.

According to the State geologist of Minnesota, the cretaceous lignite beds of Minnesota Valley are likely to afford valuable coal mines.

In the report to the Admiralty of Capt. G. S. Nares, of H.M.S. *Challenger*, dated Melbourne, March 25, 1874, Capt. Nares, speaking of the temperature of the ocean, especially near the pack edge of the ice, says:—"At a short distance from the pack, the surface water rose to 32°, but at a depth of 40 fathoms we always found the temperature to be 29°; this continued to 300 fathoms, the depth in which most of the icebergs float, after which there is a stratum of slightly warmer water of 33° or 34°. As the thermometers had to pass through these two belts of water before reaching the bottom, the indices registered those temperatures, and it was impossible to obtain the exact temperature of the bottom whilst near the ice, but the observations made in lower latitudes show that it is about 31°. More exact results could not have been obtained even had Mr. Siemens' apparatus been on board." It seems to us that the difficulty mentioned is one which would certainly have been surmounted by Messrs. Negretti and Zambra's new recording thermometers, a description of which appeared in Nature, vol. ix. p. 387; this being exactly one of the cases to which this instrument is peculiarly adapted. We believe the inventors and makers have greatly improved their thermometer since our description appeared, and no doubt means will be taken by the Admiralty to transmit one to the *Challenger*.

Mr. Pillischer, optician and scientific instrument maker, of New Bond Street, W., has been decorated by the Emperor of Austria with the golden Cross and Crown of Merit, as are cognition of his Majesty's approval of the superior quality and precision of his scientific instruments shown at the late Vienna Exhibition.

The following is a list of candidates successful in the competition for the Whitworth Scholarships (Science and Art Department), 1874:—William Martin, metal turner, Wolverton; Robert A. Sloan, engineer's apprentice, Birkenhead; William Sisson, engineer, Gateshead; Frederick Stubbs, engineer's apprentice, Derby; Thomas L. Daltry, draughtsman's apprentice, Newcastle-on-Tyne; Frederick H. Livens, engineer's apprentice, Gainsborough.

The additions to the Zoological Society's Gardens during the past week include two Tigers (*Felis tigris*) from Calcutta; two Yellow-billed Sheathbills (*Chionis alba*) from the Southern Ocean, presented by Mr. H. Roberts; a Wanderoo Monkey (*Macacus silenus*) from the Malabar Coast, presented by Lieut. Vipan; a Rose-crested Cockatoo (*Cacatua moluccensis*) from the Moluccas, presented by Mr. John Elms; three Grey-breasted Parakeets (*Bolborhyncus monachus*) from Monte Video, presented by Mr. C. Purnchard; a King Vulture (*Gyparchus papa*) from Tropical America; a Red-backed Buzzard (*Buteo erythronotus*) from South America, purchased; a Philantomba Antelope (*Cephalophus maxwellii*) born in the Gardens.

ON SPECTRUM PHOTOGRAPHY*

II.

I NEXT come to a very beautiful reflex action of spectroscopy on photography; and now I must take you back to America. I am nearly certain that everyone in this room is perfectly familiar with the name of Rutherfurd in connection with celestial photography: if you will allow me I will point my reference to him by throwing on the screen one of his magnificent photographs of the moon, which he was good enough to give me some little time ago. Unfortunately, I am not able to throw on the screen a photograph of the solar spectrum which we owe to him, the most magnificent photograph—and I say it with the intensest envy—which I think it is possible to obtain. However, I have a copy of it on the wall, and it is well worth inspection. Rutherfurd, whose name is associated with that of Delarue in the matter of celestial photography, was not content with reflectors. He lives in the centre of New York, and I suppose New York is as bad as London for tarnishing everything that the smoke and atmosphere can get at; and he came to the conclusion that he must abstain from celestial photography altogether, or else make a lens—and a lens with Mr. Rutherfurd means something over 12 in. diameter—which should give him as perfect an image in New York with 15 in. of glass, as a perfect reflector of 15 in. aperture would give him as far away from a city as you please. Mr. Rutherfurd, who never minces matters, knowing that it was absolutely impossible to get such a lens as this from an optician, who of course neglects almost entirely the violet rays—the very rays which he wanted—in constructing an ordinary telescope, determined to make such an one himself. He thought about the matter, and he came to the conclusion that in any attempt to correct a lens of this magnitude for the chemical rays, the use of the spectroscope would be invaluable. He therefore had a large spectroscope made, in order to make a large telescope, and then we have just as distinct an improvement upon the instruments which we owe to the skill of those who first adopted the suggestion of Sir John Herschel and brought together the chemical and the visual rays, as the improvement we owe to Herschel was upon the instruments which dealt simply with the visible rays. Mr. Rutherfurd simply discards the visual rays, and brings together the chemical rays; the result of his work being a telescope through which it is impossible to see anything, but through which the minutest star, down I believe to the tenth magnitude, can be photographed with the most perfect sharpness. This is the instrument of the future, so far as stellar astronomy is concerned. Having thus achieved what he wished in the construction of this instrument, and having the spectroscope, Mr. Rutherfurd commenced a research, which, I am sorry to say, he has never published, for it would be of the greatest value to any photographer or any astronomer amongst us, upon various kinds of collodion and upon the best arrangement of lenses for photographing the spectrum. Mr. Rutherfurd found that some collodions which he got were so local in their action as to be almost useless for that reason, and that others were so general in their action that they were also almost useless for the exactly opposite reason. I will now throw on the screen the line G and the lines in the green, or rather the lines approaching to the green near F; with ordinary collodions, such as one generally gets, that is to say, collodions not absolutely good, but free from both the extremes referred to by Mr. Rutherfurd, we want something like five seconds for the part near the line G. Well, when you go a little way along the spectrum in the less refrangible direction, you have to put minutes for seconds—in other words, the exposure has to be sixty times as long. I have another photograph of the spectrum, which will show you the part of the spectrum less refrangible than the line F to which I have referred. This photograph which you see on the screen required an exposure of very nearly half an hour.

Those of you who are most familiar with the solar spectrum will recognise the extreme importance of Mr. Rutherfurd's contribution to photographic spectroscopy, when I tell you that his photograph of the solar spectrum is quite as admirable and excellent as is the photograph of the moon which I have just shown you on the screen. During the last year this question of the solar spectrum has again been considerably advanced by photography in America. Mr. Rutherfurd's photographs, admirable although they are, are refraction photographs, that is to say prisms were used, and, more than this, prisms of glass. You will, therefore, quite understand that the photograph extends only a very little distance beyond the lines H. But America was not satisfied with this, and in the person of Dr. Draper, the son of the Professor Draper whose name is so honourably associated with the commencement of work done in photography thirty years ago, has just now photographed the solar spectrum far beyond H. A copy of his photograph is on the wall, but unfortunately I have not a copy which I can throw on the screen.

---

* Continued from p. 112.

I have already referred to the extreme importance of photography in astronomy, and the point that I wish to urge to-night, after what I have stated regarding all the work which has been done up to the present time, is this—That what photography has been in the past to astronomy—what it will be in the future no one can say—such can photography, and such must photography, be to chemists and physicists. Of course, in the way of photographic application, it is scarcely fair to say that a daily photographic record of the prominences around the sun is a question either of physics or of chemistry. But still the method which enables us, or which, I hope, will enable us shortly, to obtain a daily photograph of every prominence which bursts out—although absolutely invisible to our eyes—on the sun, is a method which depends on physical laws, and has nothing to do with astronomy in the ordinary sense. If you will allow me, I will show you now on the screen a photograph of a drawing which was made by an eminent Italian observer in India during the last eclipse. It is a drawing made by Prof. Respighi, of the sun's corona, as seen by the spectroscope; and I hope in the next eclipse we shall not any longer have merely drawings to refer to, but that we shall have a photograph which can be brought here, and which will let us know exactly how the matter stood. You see there on the screen three rings—a red ring, a green ring, and a blue ring. They are red, green, and blue, because the element in that part of the sun's atmosphere—hydrogen—gives us lines in the red, green, and blue; and they are rings because the hydrogen atmosphere extends in the most admirably regular way all round the sun. In fact, we may say that, in observations of this kind, we use the corona instead of the slit, and if that is good for the corona it is perfectly obvious to you it is good for the chromosphere—for the brighter regions lying closer to the sun than the corona does—as we know that it gives a line of intense blue, exactly where photography, as it is generally carried on, has its strongest *point d'appui* in the spectrum; and it is quite clear to you that we ought to be able to get a photograph of this every day, just as easily as we saw it in India during the eclipse.

We will next consider the application of photography, no longer to the mere solar spectrum, but to the physics of the sun. What is the solar spectrum? It is the continuous spectrum of the sun, minus certain portions where the light of the continuous spectrum has been absorbed. What have been the absorbers? The gases and vapours, generally speaking, in an excessively limited zone of the sun's atmosphere, lying close to the bright sun we see; close, I say, to the photosphere. This zone is called the reversing layer. Then if the solar spectrum is the result of the absorption of this reversing layer, what will happen to the solar spectrum if the constitution of the layer changes? Obviously a change in the solar spectrum. Now, recent researches carried on by means of photography show us that if you take any particular vapour in the reversing layer, which you may call A, for instance, and then assume that the quantity of A in the layer is reduced, the absorption of that particular vapour will be reduced; what then will be the result on the photograph of the solar spectrum? Some of the lines will disappear. Suppose that this particular vapour which we call A, instead of being assumed to decrease in quantity, increases in quantity, what will happen to the solar spectrum? The same researches have told us that as its quantity increases its absorption will increase, and that its increased absorption will be indicated by an increase in the number and in the breadth of the lines absorbed. What, then, will happen to the solar spectrum if any change of this kind is going on? The photograph of a solar spectrum taken, say, to-day, may be different from the photograph of the same part of the spectrum taken at some distant period. What is the distant period we do not yet know—whether three months, six months, six years, or eleven years; but, at all events, there is reason to think already that if we had a series of photographs of the solar spectrum, taken year by year, we should see great changes in the spectrum. Allow me to show you a photograph of a very limited portion of the solar question, and I will prove my case; and let me tell you I could not prove my case if photography had not been called in, because if the existence of any particular metal, or of the increase of any particular metal, depends on such a small matter as one line among 10,000, what will happen if a man neglects to observe this change? People will say, "Oh! in a research of that kind it is altogether excusable if he has made a mistake." But if you have a series of phenomena recorded by means of a camera on "a retina which never forgets," as Mr. Delarue has beautifully put it, and if you compare those pictures day by day, and year by year, the thing is put beyond all question when you get one line disappearing, or another line appearing.

Now we have before us a part of the solar spectrum near the line H, and I wish to call your particular attention to one line. We have admirable drawings of the solar spectrum taken about the year 1860. If the draughtsman was recording by means of his eye the lines in the spectrum, he would not be very likely to overlook a line darker than some he inserts, but he might easily overlook finer lines. Now, it is a fact that in the most careful map that we have—a map drawn with a most wonderful honesty and splendid skill—a line is absent in the region indicated, which line is now darker than some that were then drawn, and that line indicates the presence of an additional element in the sun—strontium. I do not make this assertion thinking that subsequent facts will show the drawing to be wrong, but because I see reason to believe that what we know already of the sun teaches us that it is one of the most likely things in the world that strontium was not present in such great quantity in the reversing layer when the drawing was made; but, however that may be, I think you will see how important it is that this photograph, which I have just thrown on the screen, should be compared with photographs made five, ten, fifteen, a hundred, or two hundred, or as many years as you like ahead, and it is in this possible continuity of observation of the solar spectrum, carried on for centuries, that I do think we have in photography not only a tremendous ally of the spectroscope, but a part of the spectroscope itself. Spectroscopy, I think, has already arrived at such a point, at all events in connection with the heavenly bodies, that it is almost useless unless the record is a photographic one. I am glad to say that only to-day I have had a letter from Dr. Draper, who tells me he has at last succeeded in getting an admirable photograph of the spectrum of a star. Now that is of the very highest importance, because the sun is nothing but a star, and the stars are nothing but distant suns; and as long as we merely investigate the sun, however diligently or admirably we do it, and neglect all the others, it is as if a man who might have the whole realm of literature to work at should confine himself to one book, and that book probably not a good representative of the literature of the country he was examining into.

So much for the application of photography to what may be called the celestial side of spectroscopy; but let me tell you that this, so far as spectroscopy is concerned, does not exist. To the spectroscope all nature is one, and it is absolutely impossible to make a single observation, either on a sun, or a star, or a comet, without bringing chemical and physical considerations into play; and it will be a regrettable circumstance if chemists employ the spectroscope in terrestrial chemistry—they have not done much in that way yet—without taking the sun and all the various stars of heaven into counsel, because the spectroscope is absolutely regardless of space, and shows us that the elements which are most familiar to us here, or at all events a good many of them, are present in the most distant stars, and the spectroscope shows us those elements existing under conditions which are absolutely impossible here.

There is another point, too—spectroscopy is, above all things, molecular. We are dealing with the ultimate atoms, or molecules, or whatever you like to call them, when, by means of the spark, we drive a substance into vapour. And if chemists, for instance, will simply ask themselves which substances have their lines reversed in the solar spectrum, I think, before they have thought that problem out—that very simple problem, as it seems—there will be such a flood of light thrown upon terrestrial chemistry, that the only wonder will be that it has not been seen before, years and years ago. These, you will say, are theoretical applications. It is perfectly true; and there are a great many other theoretical applications that it would be my duty, as it would be my pleasure, to bring before you, if time permitted. But that is not all. I have to refer to the application of the spectroscope in what are considered by some people more practical directions. The more you deal with the most abstruse considerations of Science, the more likely you are to get practical applications out of them.

You have already seen how exceedingly important it was to use a slit instead of a round hole in these experiments. It was the verdict of Wollaston, and it was the verdict of Becquerel and Draper, as I have shown you to-night with regard to photography. You have also seen that we can use the circular corona as a slit equally well.

Now if we take a long slit and divide it into as many portions as we choose, we see at once the improvement that we introduce into spectroscopic photography. All we have to do is to divide that slit into portions, as it were, by letting a window run down the slit, and when the window has arrived at the second part of the slit, let in light from a new source. This principle has been carried out practically in the following manner:—A rectangular brass plate 71 mm. long, and 35 mm. broad, slides in grooves in front of the slit of the spectroscope, and a window 4 mm. high, cut out of this plate, leaves a portion of the slit of this length exposed. A small pin presses firmly against the face of one of the sliding plates, and a row of small shallow holes or notches is drilled in the plate so as to intercept it in its upward or downward movement at those points where the pin falls into a notch. The distance between the notches is precisely the same as the height of the opening cut in the sliding plate, so that the movement of this plate from one notch to another corresponds to a distance equal to the height of the exposed part of the slit, and the spectra compared are confronted, so to speak, absolutely; the upper edge of one spectrum abuts against the lower edge of the other, and the coincidence, or want of coincidence, between lines in the two spectra can thus be determined with the greatest precision. The spectroscope employed contains three prisms of 45° and one of 60°; its observing telescope is replaced by a camera with a 3-in. lens by Dallmeyer of about 23 in. focal length for the use of which I am indebted to Lord Lindsay. With this arrangement—the spectrum being received upon a sensitised ¼ plate—the portion between the wave-lengths, 3,900 and 4,500, can be obtained at once in good focus. A ray of sunlight, reflected from a heliostat mirror so as to fall upon the slit-plate, is brought to a focus by means of a double convex lens just between the carbon poles of an electric lamp, while a second convex lens placed between the lamp and the collimator tube, serves to cast an image of the sun or of the electric arc upon the slit-plate. Supposing, now, we wished to compare the iron spectrum with that of the sun: the sun's image in sharp focus on the slit-plate is first allowed to imprint its spectrum on the prepared plate. The ray of sunlight is then cut off, the sliding plate moved up or down till the pin catches in the next notch, and the image of the arc, passing between an upper pole of carbon and a lower pole consisting of a carbon crucible containing a fragment of iron, is allowed to fall on the portion of the slit thus exposed.

Let me show you some photographs illustrating this description. Here is a single photographic plate on which the new method has enabled us to register no less than four different spectra; those of you who are familiar with photographic processes will immediately see how it is that the number is not forty instead of four. Having a slit of a certain length, if I open all the length of that slit at once I should get a spectrum the breadth of which would depend upon the length of the slit; but if I commence operations by allowing the light first to come through one small portion of the slit, then we shall get the light from the particular metal which I employ in the electric arc falling on one part of the plate, and registering itself on the photographic plate. Then, if I close up that part of the slit, and open another one, I shall be able, through that newly opened part of the slit, all the rest being closed, to photograph on the plate the spectrum of another substance, say iron. Then, having used up that part of the plate, I can close that portion of the slit, I can bring my window lower down, and there we have the spectrum of cobalt. The window has been brought farther down, and there we have the spectrum of nickel, so that we have, as the work of some eight or nine minutes at the outside, a photograph—not a perfect one in this case, but this was the first one taken on this method—which will register with the most absolute and complete accuracy and certainty not less than 1,000 lines. Now a careful student of those lines, working as hard as he can, thinks himself very fortunate if he can lay down ten an hour. Therefore, as ten an hour are to 1,000 in seven minutes, so is the eye to photography in these matters.

I have a photograph of a somewhat similar nature, which I am anxious to place before you. We have here an absolute comparison rendered possible, by means of photography, between the lines of the spectrum of iron and the lines of the spectrum of the sun. You see that in the case of most of the thick lines, you get a thick line in the solar spectrum corresponding with the lines of the iron. And, more than this, you see, I hope, all of you, that these lines of iron are of different lengths. The reason of that is that I have been careful to photograph on the plate the lines due to the various strata of iron vapour, from the rarest vapour, which is obtained at the outside of the electric arc, to the densest, which occupies the centre of the core, and you will see the most beautiful gradation as we pass from the outside part of the spectrum to the inside. This inside part represents the complete spectrum of the core, and the outside the incomplete and almost mono-chromatic spectrum of the vapour which surrounds the denser core in the middle of the spark; thus we have practically reduced the spectrum of iron to one line, instead of 460. That is the first photograph of the kind which has been taken; I say that, not because I am proud of it, but because you all know how enormously photographic processes are likely to be developed the moment, not one individual, but a great many, try their hands upon them, so that an enormous improvement upon what you now see may be anticipated. Not only have we developed, in the application of photography to spectroscopy, a valuable ally to Science, as we have in the application of photography to astronomy—and you know what that has done, and what it is going to do—but we have, I believe, what we may almost call a new chemistry, some day to be revealed to us by means of photographic records of the behaviour of molecules. Recollect that the difference between the iron spectrum of one line and the iron spectrum of between 400 and 500 lines is simply due to the difference in the arrangements of the molecules or atoms of iron in the centre of the electric arc and its exterior. There is one question which all lovers of the spectroscope may ask of photographers, and that is this, why should we any longer be confined, in registering spectra, to the more refrangible end of the spectrum, when one of the very first spectra of the sun that was ever taken was a complete photograph of the spectrum, including not only the blue, the green, and the yellow, but the red, and the extreme red? I think that if photographers will study the action of light on molecules, and read that extraordinary paper of Becquerel's, and will give those who are familiar with the spectroscope, and those who are anxious to promote the progress of spectroscopic research, a means of extending photographic registration, not only into the green part of the spectrum, which they do already with difficulty, but to the extreme red, then the use of the eye will almost entirely be abolished in these inquiries. And although no one has a higher estimate than myself of the extreme importance of the eye, I think that the more it is replaced by permanent natural records in these inquiries, the better it will be for the progress of Science.

J. Norman Lockyer

SCIENTIFIC SERIALS

The current number of the *Quarterly Journal of Microscopic Science* contains several papers of interest. Dr. Michael Foster commences with an article On the term Endothelium, in which he proves that the word is etymologically pure nonsense, Ruysch's word epithelium signifying that it covers papillæ. His endothelium must be understood to mean *that it is inside a papilla.* It is also valueless for other reasons: for if it is defined as that epithelium developed from the germinal mesoblast, the epithelium of the Wolffian ducts, of the ureters, and of Muller's ducts would have to be included. Therefore the term is insignificant and must be abolished. *Monoderic* and *polyderic* are proposed as terms to indicate that the cells form one or several layers.—The second part of Prof. Haeckel's interesting Gastræa theory follows, in English. In it the systematic and the phylogenetic signification of the Gastræa theory and the ontogenetic succession of the system of organs are discussed, as well as the bearing of the whole on the theory of types. The author is so prolific in his introduction of new words, the definitions of many of which are to be found in other publications, that a Haeckel Glossary in the next number of the *Journal* would not be out of place, to assist readers in the full appreciation of that illustrious biologist's very suggestive theory.—Mr. J. W. Groves explains his method of arranging and cataloguing microscopic specimens.—A paper follows by Mr. E. C. Baber On picro-carminate of ammonia as a microscopic staining fluid, in which he explains M. Ranvier's method. The great advantage of this reagent is shown to consist in its staining tissues in a series of colours varying from red